Laboratory Courses of Instruction.

BY JOHN M. COULTER.

In speaking of courses of instruction in botany and the methods used, no reference is made to the old "book methods" of teaching the subject, but simply to what are known as laboratory methods. With this restriction three distinct methods are observable in our laboratories. The first will be understood when it is called "systematic botany"; the second is at the other extreme and ignores systematic botany, being a study of structures and the phenomena of life; the third tries to combine the best elements of both. In some laboratories "cryptogams" are unknown, while in others phanerogams are hardly thought to be worth studying. The second method is a natural reaction from the first, while the third represents the counterswing of the pendulum, the most modern phase, and as we expect, the botany of the future. The fact of it is, botany has grown to be so large a subject, that one teacher with the most liberal allotment of time can not compass it all, even in an elementary way, and he rightly presents that phase of it in which he himself is most interested, as, of course, that seems to him the most important. The only laboratories in this country that can pretend to compass the subject are those at Cambridge, where several instructors are provided. Probably the most satisfactory presentation of the subject will be to select representative courses of instruction from several that have been sent, as expressing the ideas of as many experienced teachers of botany. These courses are taken from those laboratories where but one teacher is provided, and where the time varies from one term to three or four years. In most cases the study is a compulsory one for a short time, but all advanced and really good work is done by students who "elect" the study and pursue it for some time.

In reference to those who have but a term or two to devote to the study, three methods are pursued. One is to use a textbook or lectures and then direct all laboratory work towards the so-called "analysis" of plants, which means, of course, the comparison and naming of phanerogams. This may be called the oldest method and is vastly better than nothing. Another plan is to have the laboratory work all directed towards the examination of facts called for in lectures, such as leaves, branches, roots, etc. This method is practiced in two ways, either as corroborat-

ing statements already given in lectures, or preliminary to such statements. The latter is much the better way, and has been well elaborated by Prof. Beal in his paper on "The New Botany." A third method is to have the class examine a few types of structure from the lowest to the highest, and thus get some general notion of the structure of the vegetable kingdom, as well as the broad outlines of its groups. The last would commend itself as a very philosophical way of treating the subject, if the object is to study botany, and not one department of it.

For work extending through a greater time, such as is obtained in well equipped botanical laboratories, the following courses, already in use in different institutions, are presented. No names are used, as the courses are only selected as types, of which there are many modifications, but they represent very well our present methods of instruction.

1. Beginners use the facilities of a well-equipped laboratory to enable them to master the subject of assigned "lessons" in some text-book like Bessey's Botany. Each man is told to feel free to take up any part of the topic, although advice is given as to what may be preferable. But in every case *the student* decides what he wants to do while he is in the laboratory. Material is provided for all parts of the general topic of study. The student is counseled to familiarize himself with as many types as possible, but he is encouraged to go deeper into a matter here and there, as interest or opportunity may lead him.

Advanced students are advised to take up particular subjects, and to work them out with thoroughness. Here the rule is to select one topic only, or at most a small group of topics, and to get the desired training by great accuracy and attention to all details. The results in such cases are brought together finally in a paper illustrated by the drawings made during investigation.

2. Beginners are started by having them examine a flower, a seed, a plantlet, a naked branch, anything, in fact, that is convenient or in season. Reports of the discoveries made are given before the class and discussed, the teacher directing all these results toward definite and correct conclusions. No order of text is followed, but simply the order of convenience. The literature of the subjects examined is constantly consulted, though generally after the examination has been made. Soon some topic is assigned, which the student must "work up" by observation and present in a final paper.

For advanced students the work is of a similar nature, but closer observation is demanded and a stricter attention to details, and the study of comparison of structures is strongly urged.

3. Beginners are put to work substantially upon the plan introduced by Huxley and Martin in their "Elements of Biology." Of course different plants are used from year to year. One teacher mentions that a great favorite for beginning the study of vascular plants is *Equisetum hyemale*. Throughout the course the student makes all of his own preparations except a few that require special delicacy of manipulation. Accurate drawings and carefully written descriptions are required and are handed in from time to time for criticism and suggestions. In this way the work is done until the student has acquired a critical knowledge of types selected from all the leading groups of the vegetable kingdom.

Advanced students are then called upon to select some group or groups for special study, usually some group of flowerless plants, as needing more aid from the teacher. In the course from which these facts are taken fungi are usually studied, the student making a thorough study of a few representative species, then identifying fifty or more (generally the parasitic fungi), and finally becoming as fully acquainted as possible with the modern literature of the subject. The whole object, and it is an admirable one, is to see that each student learns how to conduct an investigation and use a library. Then follows, if time permits, special investigations and published work.

4. Quite an elaborate course is as follows: The work for the first year consists of systematic work three hours a week and recitation in Gray's Botanical Text-Book, Vol. I. Next is taken up Goodale's Physiological Botany, with histological and physiological work. Along with this a course of lectures on general classification is given, and Bessey's Botany furnishes collateral reading. This occupies the second year. Then, if the student proposes to enter the medical profession, he is directed to a study, analytical and microscopical, of our native medicinal plants. If, on the other hand, he has an aptitude in that direction, and is simply pursuing botany from a biological standpoint, he goes into a study of life histories of the lower plants.

5. Beginners receive a course of lectures on general botany, accompanied by laboratory work on structures illustrative of the lectures and anticipating them. In this way the broad facts of phænogamic structures and life are brought out. This is followed by work in systematic botany, chiefly with the view of teaching methods of "analysis," the reasons for groupings of so many different grades, and the recognition of great groups at sight.

A second year is then spent in the exhaustive study of plant types, one or a few being selected from each group, and all through

the course careful drawings and descriptions are demanded, and frequent lectures attempt to weave together all the facts so as to present the development of the vegetable kingdom and its adaption to habits and surroundings. A library in the laboratories contains all standard books of reference, and a knowledge of the literature of the subjects studied is never lost sight of. At the close of this course papers are prepared upon various subjects that must be presented in a comparative or developmental way, such as "sexual reproduction," "asexual reproduction," "alternation of generations," "development of vegetative structures," etc. During a third year special students select any subject they may feel an interest in or have an opportunity to investigate, the teacher simply seeing that it is not too ambitious or useless.

In the above courses much detail has been necessarily omitted. Other courses differ from them chiefly in the order of presenting subjects. Where and how to begin the study are things not well settled, but in the long run about the same things are taught.

It will be noticed that in the above courses physiology plays but little part, a fact chiefly explained by lack of appliances and lack of time. We venture to predict that if at the end of the next decade the GAZETTE undertakes to give an account of our botanical laboratories, that not only will physiology be found to be well cared for, but other departments not even mentioned in this paper will be prominent.

We can not too strongly emphasize the importance of having the botanical library in the laboratory, that the student may at least become acquainted with the names of writers and their books, and best of all with the literature of the subjects they are investigating.

Several teachers desire to learn subjects which have been of use in the work of special students. For this purpose the following have been presented and their number could be indefinitely increased.

"Structure and development of Onoclea Struthiopteris"; "Influence of climate on vegetation"; "Water in plants"; "Development of stomata of monocotyledons"; "Distribution of the vascular bundles of ferns"; "Biology of the vegetable cell"; "Pathological changes induced by parasitic fungi"; "Development of the pollen-tube in monocotyledons, with the nature and descent of the nuclei"; "The Perisporiaceæ of the region"; "Conjugation of Spirogyra"; "The fibro-vascular system (as a skeleton) of some dicotyledon"; "Water and salts in the various tissues of some plants"; "Plant crystals"; "Development of any

embryo"; "The anatomical study of any plant (not at any one phase, but its anatomical development)"; etc. In addition to these attention should be called to the subjects suggested by Prof. Beal in his "New Botany" already referred to.

If any different ideas in the way of laboratory courses of study, or subjects for special work, can be called out by this article, the GAZETTE will be glad to give them room.

Section Cutting.

BY T. J. BURRILL.

Botanists as a whole seem to be far behind the zoologists in the matter of microscopical technic, especially in the preparation of material. Witness the literature upon injecting, staining, hardening, imbedding, infiltrating, fixing, cutting, handling, clearing—nearly all of it directly for or copied from the animal histologist.

No doubt this comes about naturally enough. In the first place animal tissues require a greater diversity of treatment, and to reach the highest results he who works especially upon them must have resources at command little dreamed of by those whose attention has been exclusively occupied with vegetable preparations. Then those who have earnestly worked upon the minute structure of plants are outnumbered many times by the skillful and intensely devoted animal histologist. The very fact that man's body is animal rather than plant, stimulates investigation on the former instead of the latter side.

But however it may be accounted for, botanists and vegetable physiologists, with only exceptions here and there, are much disposed to remain content with the early methods and processes which zoologists (perhaps zootomists is the word) now consider primitive and superseded. For myself I can not help feeling that I shall gain much by following, where I can not make better headway for my special purposes by special methods, the lead of my brothers, the animal histologists. Fixing my thought now upon simple work for the student botanical laboratory, I restrict myself to my theme. Nothing new is offered. What follows is simply some account of results from personal experience as student and instructor.

The first requisite for good section cutting is an *edge*. In a very large number of instances sections for microscopical study